GLOBALLY-CONSTANT SPEED OF LIGHT C : A BONANZA IN PHYSICS

Otto E. Rossler

Faculty of Science, University of Tubingen, Tubingen, Germany

Abstract

The historical twist that the universal constancy of the speed of light, c , got abandoned for more than a century is recalled. The proposed new situation – global constancy of c – is described in some detail. Its uplifting consequences include a new metrology and a new cosmology.

Keywords: Equivalence principle revived, 2-pseudosphere, Flamm-paraboloid , Noether theorem, Big bang replaced

Every layperson believes that the speed of light is a universally valid constant – after Einstein had shown it to be so, in the footsteps of Lorentz and Poincaré, in his special theory of relativity of 1905. However, this simple situation lasted only for two years. In 1907, Einstein began to investigate gravitation. He realized that a bridge towards a better understanding of gravity is offered by kinematic acceleration. Einstein showed by means of a thought experiment that in contradistinction to clocks located at the tip of a constantly accelerating long rocketship in outer space, clocks located at the rockettship's bottom tick slower (e.g. half as fast) [A. Einstein,1907]. This was "the happiest thought of my life," Einstein would always say. This breakthrough allowed him to understand the riddle of gravitation in terms of the theory of special relativity found two years before.

To his own dismay, Einstein then saw himself forced to realize that at the bottom of the long rocketship, the local slowdown of time is accompanied by a numerically equal (and visible from above) reduction of the transversal speed of light c . This despite the fact that c represents a universal constant in special relativity, and even though nothing but special relativity had been used in describing the rocketship's behavior. (The two changes observable from above, the slowdown and the crawl , remain imperceptible locally.) The drawback of the reduced c more downstairs in gravity caused Einstein to drop the subject of gravity for 4 years (until his good friend Paul Ehrenfest could lure him back with the related paradigm of the rotating disk). Einstein then carefully built around the drawback encountered. The simplest nontrivial solution of the finished Einstein equation of general relativity, the Schwarzschild metric, can indeed be written in a mathematically equivalent form in which c is a global constant [O.E. Rossler,2008].

How about the remaining riddle of the “creeping” speed of light downstairs in the rocketship and in gravity? The solution to this conundrum follows from a glance at the well-known “Lorentz contraction” of special relativity. It states that a fast-moving car is shortened in the forward direction while keeping its width. Does this fact perhaps mean that the shortened car has become anisotropic in its own frame? The answer given by special relativity is no. In the same vein, the seemingly only vertically enlarged “spaghetti people” with their slowed-down clocks, observable from above in the rocketship (and by implication in gravity), remain undistorted in their own frame. They are objectively enlarged in all directions – not just vertically – as we shall see below –, but the transversal size change is "masked" when viewed from above. Thus, c only seems to be creeping in the lateral directions downstairs without being actually reduced. Einstein could not possibly see this state of affairs in 1907 because quantum mechanics did not exist yet.

The new size change – which ultimately implies universal constancy of the speed of light c in general relativity – was spotted from time to time in history (cf. [O.E. Rossler,2008]). The most convincing mathematical demonstration based on the theory of general relativity was given by Richard J. Cook in a paper entitled “Gravitational space dilation” [R.J. Cook, 2009]. A very simple derivation based on the equivalence principle is the “Telemach theorem” [O.E. Rossler, 2012]. Its cousin, the “Olemach theorem” [O.E. Rossler,2013], is even simpler since it only invokes angular-momentum conservation and quantum mechanics.

Let me summarize briefly (cf. [O.E. Rossler,2013]): Rotation symmetry” applies at all levels inside the rocketship. This symmetry via Nether’s theorem implies angular-momentum conservation. It suffices to look at the special case of a horizontally rotating frictionless bicycle wheel, freely suspended at its hub, that can be hauled up and down adiabatically. Its angular momentum, L ([P.A. Tipler, 1991], Eq. 8.32) is conserved:

$$L = \omega m r^2 = \text{const.} \qquad (1)$$

Dependent on the wheel’s momentary height level, its rotation rate ω is (like any other clock rate) reduced by the Einstein redshift factor that locally applies relative to the tip of the rocketship. In addition, we have learned from Einstein [1907] that all locally emitted photons are redshifted (reduced in their frequency and hence energy) by that same factor. This follows from the reduced ticking rate of the atoms producing them. As a consequence of the locally reduced photon mass, all local masses m are reduced by the redshift factor. This not very familiar fact can be illustrated best by the special case of positronium creation and annihilation (of particles from photons and of photons from particles, respectively). This quantum law applies at every height level; note that the familiar "PET-scan" machine which relies on positronium annihilation can be operated on all height levels. Hence in Eq.(1), m is reduced by the very Einstein redshift factor by which ω is reduced. The decrease of ω and m by the same factor in Eq.(1) entails that r is increased by the same factor in compensation (since it enters Eq.1 in squared form). Along with r, all local lengths s are increased. They are increased by the same factor by which also the local time intervals t are increased. Therefore, the ratio "length-over-time" (s/t) remains the same, not only locally but globally. Hence the speed of light c is globally constant in the equivalence principle. Since the described rotation experiment carries over from the accelerating long rocketship of the equivalence principle to gravity proper in a high tower and on a neutron star, the result holds true also in gravitation. The Schwarzschild metric is the most important special case since it involves an infinite redshift (at the surface of a non-rotating black hole) in general relativity. If c is constant in the Schwarzschild metric, there can be no doubt that general relativity at large complies (although this much harder step remains to be demonstrated in detail).

The global constancy of c shown to be valid in gravitation has important secondary consequences. Its most stunning implication is the fact that the well-known infinite time delay of a light pulse that goes all the way down to a black hole's horizon (or back up from it) [J.R. Oppenheimer et al, 1939] now reflects the presence of an infinite distance between the outside world and the horizon. (The surface of a black hole is called "horizon" following Wolfgang Rindler.) Therefore, the famous rotation paraboloid ("Flamm's paraboloid"), which traditionally characterizes the shape of space-time around a Schwarzschild black hole, gets extended (morphed) into a "generic 2-pseudosphere." The (halved, to be precise) 2-pseudosphere has the shape of a vertically held infinitely long trumpet. The trumpet's flattening upper end coincides with the uppermost part of the rotation paraboloid of Flamm's. Next, picture an ant placed on the almost flat rim of the trumpet's mouth: the ant can walk around the rim in a short finite time. However, the same ant has to cover an infinite distance in order to reach the middle of that same, everywhere locally planer, surface, namely the "mouthpiece" of our infinitely drawn-out trumpet. This maximally remote inner end of the trumpet represents the horizon of the black hole. Thus not only "curvature" goes to infinity at the horizon, as is well known, but so does "stretching." Both local features thus go to infinity hand in hand, in the constant-c differential geometry of the Schwarzschild metric.

Important implications follow from the new global constancy of c in the Schwarzschild metric as the simplest and most important solution of the Einstein equation. In the first place, both rest mass m and charge q scale in inverse proportion to the local redshift factor, going towards zero in tandem at the horizon [R.J. Cook,2009]. The rest-mass change was already explained. The charge-change if true represents a major surprise – after a 1½ century-long reign of the "law of charge conservation in physics." The reason for this "scandal" in a good sense lies in the well-known universal constancy of the mass-to-charge ratio valid for every class of elementary particle. It is valid in every inertial frame and hence also when the particle is freshly released into free fall in gravity (and even when it is still locally fixed, in accordance with Einstein's famous postulate of general covariance). The newly found charge-change then implies among other consequences that the combined "Einstein-Maxwell equations" lose their physical validity [R.J. Cook,2009].

Owing to the combined size, mass and charge change, the science of Metrology acquires a whole new face. The famous "Ur-meter," the "Ur-charges" (of electrons, etc.) and the famous "Ur-kilogram" all cease to be globally valid as do other accepted constants of nature [R.J. Cook,2009]. This is the price to pay for c's re-gained universality: that other locally valid constants have now lost their global validity in compensation.

A second price to pay – or blessing if you think positive – is that all globally time-dependent solutions to the Einstein equation cease to be physically allowed when c is globally constant. Therefore, cosmology suddenly finds itself on the lookout for a replacement of the "big bang." This fact if correct amounts to a revolution of the current scientific world-view in the large – in defiance of a decades-long consensus. This last-mentioned aspect of a global constant c is perhaps the most unbelievable – and the most rewarding if correct.

The understandable surprise is taken care of by an independent result in classical fundamental physics: The recently described existence of a sister discipline to thermodynamics termed "cryodynamics." The latter applies whenever attractive (rather than ultimately repulsive) potentials govern the chaotic interaction of many particles [O.E. Rossler,2011]. It applies in particular to a "gas" of randomly moving galaxies traversed by cosmic rays and photons – as this empirically exists in the cosmos. Even when cryodynamics was still in a budding state was it already capable of explaining, in a semi-quantitative fashion, the famous Hubble redshift law along with its recently appended "Perlmutter-Schmidt-Riess hook" [O.E. Rossler et all, 2007].

But: Does the disproof of the big bang implicit in “c-global” not mean that hundreds of independent pieces of evidence accrued in cosmology over many decades must be false – a logical impossibility? Hence the “switch” just made from general relativity towards statistical mechanics must have led us astray. Surprisingly, it turns out that it is easy to identify two dozen “ad hoc” assumptions accumulated in cosmology for the better part of a century [O.E. Rossler]. This history is understandable because in the absence of the new global c , there was no compelling evidence against the expansion postulate. If Olemach [O.E. Rossler, 2013] is correct, the 24 corrections cease to look scandalous. At this place, I only adduce the first observational report from the just-finished “Alma array”: the discovery of a more than 13 billion years old starburst galaxy harboring water molecules in its old dust clouds much like any close-by old galaxy does [J. D. Vieira et al, 2013] – an observation virtually incompatible with the big bang. And there is this other, only one-week-old press release of the Planck mission that the famous “microwave background radiation” sports a giant slanted strip showing a concerted higher background temperature ([12], p. 2). This observation, which had an unpublished precursor in previous missions, harbors the potential to single-handedly topple the big-bang hypothesis on empirical grounds alone. The constant-c result therefore comes at the right time, it appears.

To conclude, Einstein's space-time theory is as fertile as it ever was. It has acquired a symmetry between “curving” and “stretching” in the equivalence principle and the Schwarzschild metric of general relativity, if the new global constancy of the speed of light c stays un-refuted. General relativity puts on a new face without losing any of its beauty in the light of the new simplification. The “trumpet” in the differential geometry of gravitation may cause a bonanza.

Acknowledgments
I thank Dieter Fröhlich, Frank Kuske and Ali Sanayei for discussions. For J.O.R.

References:

A. Einstein, On the relativity principle and the conclusions drawn from it (in German). Jahrbuch der Radioaktivität **4**, 411–462 (1907), p. 458. English translation: http://www.pitt.edu/~jdnorton/teaching/GR&Grav_2007/pdf/Einstein_1907.pdf , p. 306.

O.E. Rossler, Abraham-like return to constant c in general relativity: gothic-R theorem demonstrated in Schwarzschild metric (2008), http://lhc-concern.info/wp-content/uploads/2009/01/fullpreprint.pdf , revised http://www.wissensnavigator.com/documents/chaos.pdf . Fractal Spacetime and Noncommutative Geometry in Quantum and High Energy Physics **2**, 1–14 (2012). (Abstract and access: http://www.nonlinearscience.com/paper.php?pid=0000000148)

R.J. Cook, Gravitational space dilation (2009). http://arxiv.org/pdf/0902.2811.pdf

O.E. Rossler, Einstein's equivalence principle has three further implications besides affecting time: T-L-M-Ch theorem ("Telemach"). African Journal of Mathematics and Computer Science Research **5**, 44–47 (2012). Open access (http://www.academicjournals.org/ajmcsr/PDF/pdf2012/Feb/9%20Feb/Rossler.pdf)

O.E. Rossler, Olemach theorem: angular-momentum conservation implies gravitational-redshift proportional change of length, mass and charge. European Scientific Journal **9**(2), 38–45 (2013). Open access (http://eujournal.org/index.php/esj/article/view/814/876)

P.A. Tipler, Physics for Scientists and Engineers, 3rd edn., Extended Version. New York: Worth Publishers 1991.

J.R. Oppenheimer and H. Snyder, On continued gravitational contraction. Phys. Rev. **56**, 455–459 (1939). (Abstract and access: http://prola.aps.org/abstract/PR/v56/i5/p455_1)

O.E. Rossler, The new science of cryodynamics and its connection to cosmology. Complex Systems **20**, 105–113 (2011). Open access (http://www.complex-systems.com/pdf/20-2-3.pdf)

O.E. Rossler, D. Fröhlich, R. Movassagh and A. Moore, Hubble-expansion in static space time. Chaos, Solitons and Fractals **33**, 770-775 (2007). (Abstract and acces: http://www.sciencedirect.com/science/article/pii/S0960077906006229)

O.E. Rossler, Cosmos-21: Twenty-four violations of Occam's razor healed by statistical mechanics. Submitted.

J. D. Vieira et al., Dusty starburst galaxies in the early Universe as revealed by gravitational lensing. Nature, 13 March 2013 (Abstract and access**:** http://www.nature.com/nature/journal/vaop/ncurrent/full/nature12001.html)

[12] See http://www.esa.int/Our_Activities/Space_Science/Planck/Planck_reveals_an_almost_perfect_Universe , p. 2 (please, press the button "continue" on p. 1).